

## PD/VFC #2 --- A Detector for the Izana Transmission Monitor

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## Abstract

The PD/VFC #2, a detector for the Izaña transmission monitor, is described.

## 1 Introduction

On a recent visit [1], George Isaak and Brek Miller observed a large amount of condensation on the outside of Mark I. This has caused some concern. The condensation is a result of the proximity of the cooled EMI 9658 photomultiplier tube to the inside of the spectrometer cover. This photomultiplier is used to measure the intensity of the scattered light.

The transmission monitor uses a room-temperature EMI 9863 photomultiplier tube. It would be nice to replace the 9658 with the 9863. To do that, we will need a replacement for the 9863 transmission monitor.

## 2 Information from Richard Lines

The PD/VFC #2 was based on a design by Richard Lines [2, 3], who provides the following words of wisdom on the design of detector electronics.

I suppose it comes down to three basic points: How accurate do you need the results, what area diode do you need (in terms of optical geometry), and how bright will the source be. The best results are obviously with a bright source and a small diode. So having insulted you with the obvious...

The diode leakage current depends on three parameters: temperature, size, and doping properties. If you have sufficient light available (HeNe laser for example), even in the polarizer

nulls, then a simple TL081 current-to-voltage converter will do without any temperature control. Another way of putting this is that if the feedback resistor is  $1\text{ M}\Omega$  or less then you will not have too many problems, especially with a smallish diode ( $5 \times 5\text{ mm}$  or smaller). The photocurrent will dominate the other effects under these circumstances for all reasonable accuracy and drift requirements.

If you want to use a bigger diode then there are three options made by Centronic.

*0 Series* Same as the RS  $100\text{-mm}^2$  diode. Quite temperature dependent. These are the Narrabri diodes and were my greatest mistake with HiROS. Highest quantum efficiency at around  $0.5\text{ A W}^{-1}$  at  $770\text{ nm}$ .

*5 Series* This diode has improved blue sensitivity. Trades a small amount of quantum efficiency ( $0.45\text{ A W}^{-1}$ ) for much less temperature dependency, lower dark current, and better NEP. Recommended, as fitted in Sutherland. They do not actually need much thermal stabilization inside the spectrometer providing the water loop is operative. Much better signal-to-noise ratio at low light levels.

*7 Series* are quoted as suitable for UV use and take the *5 series* a stage further. Quantum efficiency drops to about  $0.38\text{ A W}^{-1}$  from memory but NEP, dark current, and temperature sensitivity all better again. They are square and do not come in a hermetically sealed case. I never used them on site.

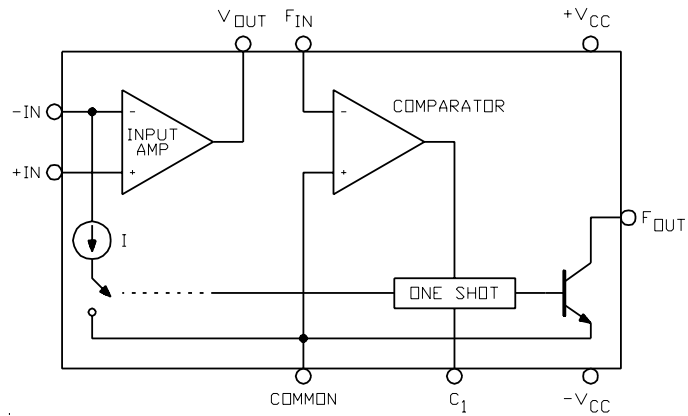
So, what to do? Ideally, go for a *5 Series* of the right size. Assuming there is no money to buy one, you will find a large *7 Series* ( $100\text{ mm}^2$ ) in an antistatic box located in the drawers to the right of where I used to sit (next to the wall). Try a  $1\text{-M}\Omega$  feedback resistor and a TL081 op-amp and you should be in business. Put it in a screened die-cast box. You may need a  $10\text{-pF}$  capacitor in parallel with the  $1\text{-M}\Omega$  resistor to stop things oscillating, (check with scope) and do not forget the decoupling capacitors around the op-amp. Veroboard is ok.

If the diode you use comes in a metal case then earth the case and accept whatever polarity the circuit produces.

Forget about temperature control with this diode.

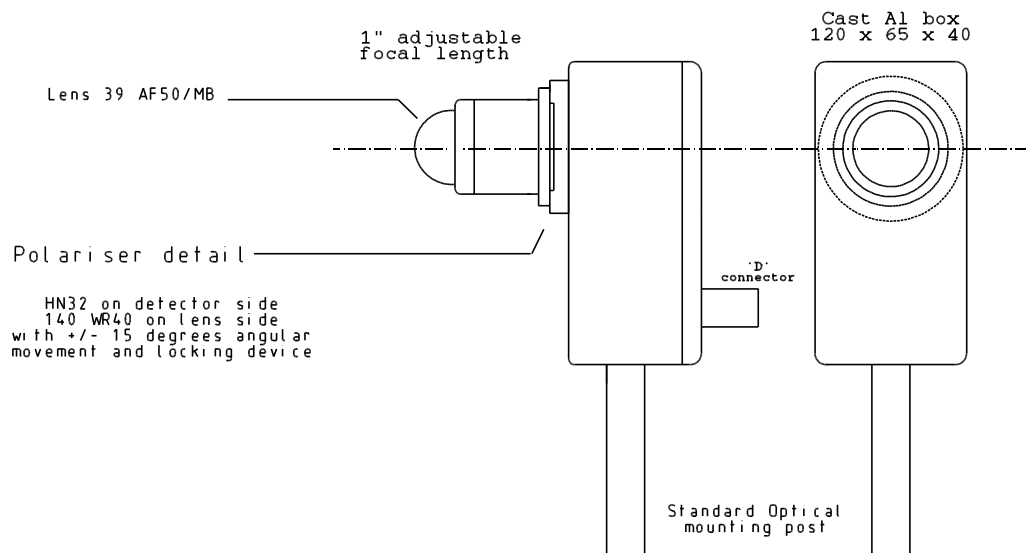
### 3 Design

For this device, a Centronic OSD100-5T  $100\text{-mm}^2$  photodiode and a Burr-Brown VFC32 V/F converter were combined into one package.



**Figure 1:** Functional diagram of the Burr-Brown VFC32 V/F converter.

## Cast Aluminium Detector Housing



**Figure 2:** The Izaña transmission monitor.

**Table 1:** Parts List

	Part Number	Description	Unit Cost
Comar	140WR40	Square, plastic, quarter-wave plate.	7.50
		HN32 Linear polarizer.	0.00
Comar	40MN00/HD	Plane mirror, protected gold, 40mm diameter.	49.00
Comar	39AF50/MB	Glass aspheric condenser, 50mm diameter.	32.50
Comar	66BR14	150mm mounting post for mirror.	2.75
Comar	66BR14	150mm mounting post for detector, cut to required length.	2.75
	it-main-1	main circuit board.	0.00

## 4 Connections

The connections to the outside world are all made via one 15-pin D-connector. The pin assignments were chosen to match the standard used by our other detectors at other sites and are shown in Table 2.

**Table 2:** Detector Connector\*

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(1	<i>Temperature sensor ground)</i>
(2	<i>Temperature sensor output)</i>
(3	<i>Temperature sensor supply)</i>
(4	<i>Peltier drive)</i>
(5	<i>Peltier return)</i>
(6	$-15\text{ V}$ )
7	Power ground
8	$+15\text{ V}$
9	Analog signal out
10	Analog signal ground
(11	<i>Offset input)</i>
12	Pulses out
13	Pulses ground
14	N/C
15	N/C

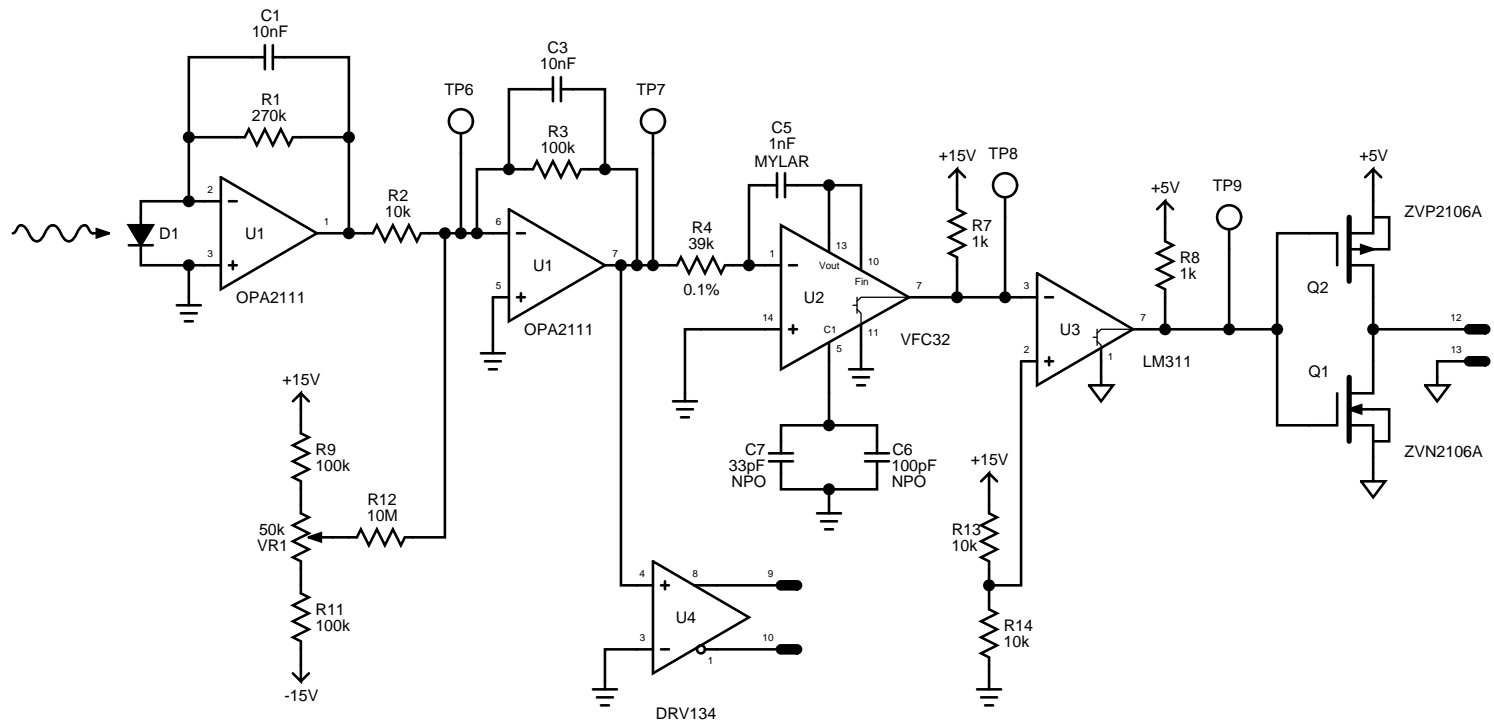
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\*15-pin male D-connector.

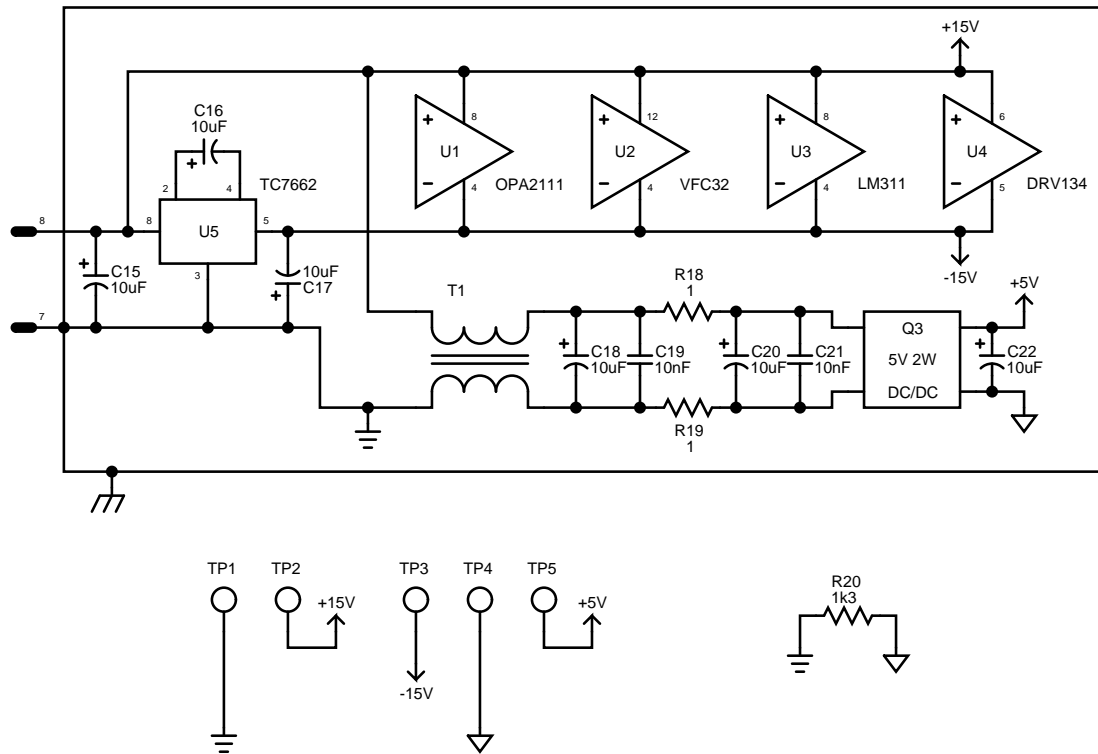


## 5 Circuit

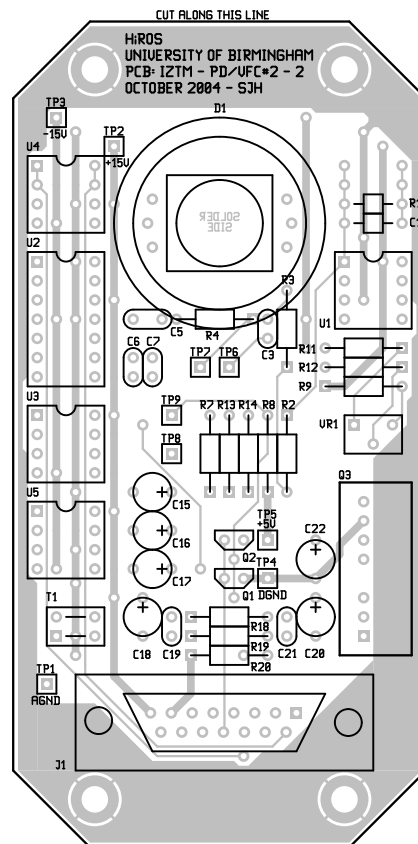
The main circuit drawing can be found in Figure 3. The power supply stuff can be found in Figure 4.



**Figure 3:** The main circuit drawing for the board inside the PD/VFC #2.



**Figure 4:** The power-supply section for the board inside the PD/VFC #2.



**Figure 5:** Main Board component layout and bottom-side tracks.



**Table 3:** Parts List

	Part Number	Description	Unit Cost
D1	Centronic OSD-100/5T	100-mm <sup>2</sup> active area blue-sensitive silicon photodetector	93.32
U1	RS 647-592	OPA2111 dual op-amp	14.37
U2	RS 809-958	Burr Brown VFC32 voltage-to-frequency converter	8.39
U3	Rapid 82-0208	LM311 comparator	0.095
U4	RS 378-2676	Burr Brown DRV134 audio balanced line driver	3.65
U5	FEC 471-2705	TC7662ACPA voltage converter	1.58
Q1	Rapid 47-0156	ZVN2106A n-channel MOSFET	0.22
Q2	Rapid 47-0174	ZVP2106A p-channel MOSFET	0.29
Q3	Rapid 84-2420	Recom RS-1205S 2-W 12-V-to-5-V wide-input, single-output DC-to-DC converter	10.20
T1	RS 308-8738	double interference suppressor	1.27
R1		270-k $\Omega$ resistor	.
R4	Rapid 63-1570	39-k $\Omega$ 0.1% resistor	0.14
R12		10-M $\Omega$ resistor	.
R18, R19		2x 1- $\Omega$ resistor	.
R20		1.3-k $\Omega$ resistor	.
VR1	Rapid 68-1116	50-k $\Omega$ PV37W pot	0.47
C5	Rapid 10-0900	1-nF mylar capacitor	0.011
C6	Rapid 08-0940	100-pF NPO ceramic capacitor	0.028
C7	Rapid 08-0930	33-pF NPO ceramic capacitor	0.028
	Rapid 15-0555	15-way D-plug straight PCB mount	0.44
	Rapid 85-1744	15-V 500-mA regulated power supply	6.75
		2x 1-k $\Omega$ resistor	.
		3x 100-k $\Omega$ resistor	.
		3x 10-k $\Omega$ resistor	.
		6x 10- $\mu$ F capacitor	.
		4x 10-nF capacitor	.
		14-way DIL socket	.
		5x 8-way DIL socket	.

## 6 Installation and Alignment

There are two stages to aligning the detector. The first is orienting the quarter-wave plate with the polarizer, and the second is orienting the whole detector.

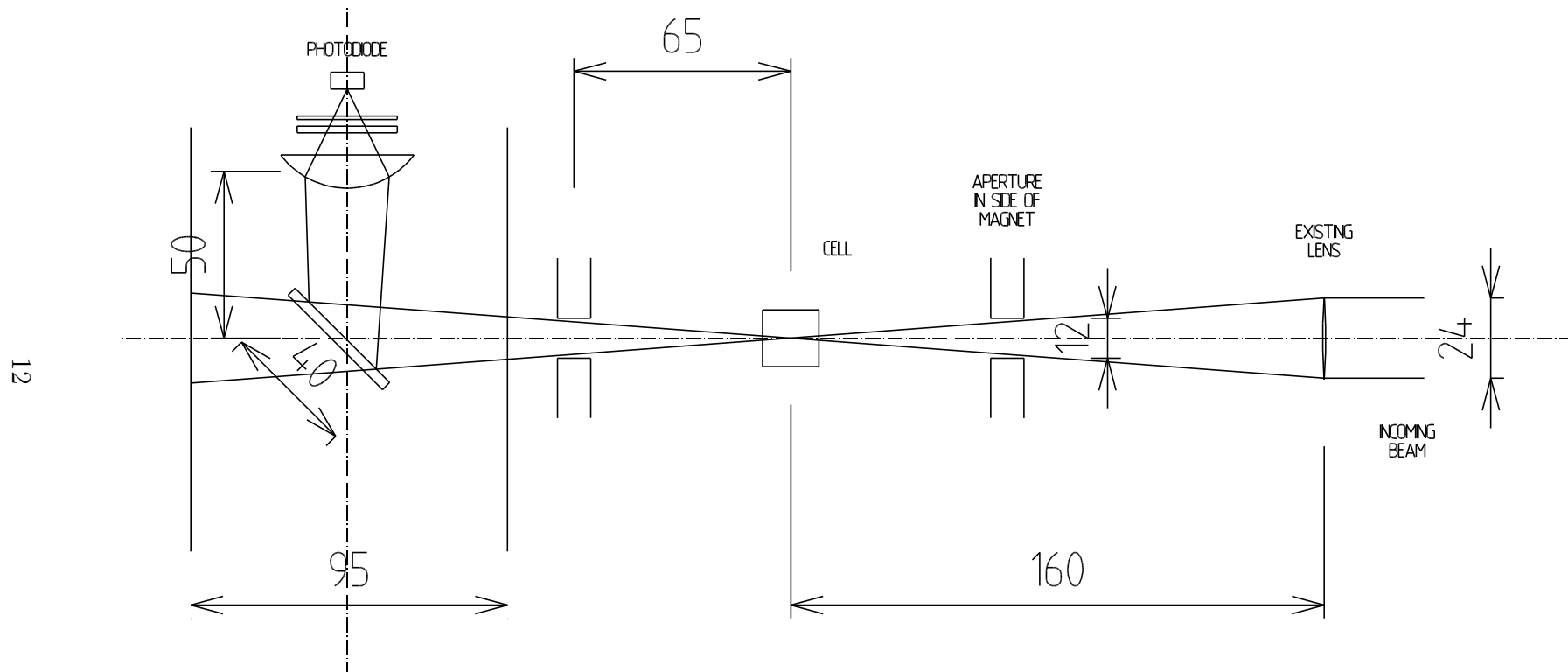
The alignment of the quarter-wave plate with the polarizer should only have to be done once, unless the optics mounted on the detector are removed. The alignment was done by looking at the beam through the instrument and observing the alternate high and low intensity caused by the switching of the Pockels-cell state. This adjustment should be made observing the beam via the mirror to help include the effects of polarization by reflection.

When the fast-axis of the quarter-wave plate is correctly aligned at  $45^\circ$  to either of the axes of the linear polarizer, the beam will appear to alternate between maximum high and maximum low intensity. Ideally at this point the ratio of the two intensities should be approaching 100%. However, the best ratio that could be achieved was around 66% mainly due to the effect on the polarization by the mirror.

The alignment of the detector as a whole is somewhat easier. The mirror was aligned by looking down along the optical bench on which the detector would be mounted, and adjusting the mirror until the view through the aperture in the side of the magnet was correct. The detector was then mounted and the analogue output connected to an oscilloscope. By moving the detector and looking at the trace on the CRO it is possible to find the position of maximum intensity and thus the correct position of the detector.

## References

- [1] GEORGE R. ISAAK AND BREK A. MILLER. The grand opening of the Izaña Zoo in 2003 December. *BISON Technical Report Series*, Number 222, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, March 2004.
- [2] RICHARD LINES AND BREK A. MILLER. Scattered-light detector manual. *BISON Technical Report Series*, Number 47, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, February 1996.
- [3] BREK A. MILLER AND HUGH K. WILLIAMS. PD/VFC #1 — A detector for Pockels-cell testing. *BISON Technical Report Series*, Number 82, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, July 1998.



**Figure 7:** Plan view of Mark I.